Synopsis of

ANN BASED MULTICLASS OBJECT CLASSIFICATION OF DEFORMED AND DEGRADED IMAGES

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1. Introduction-

In Artificial Neural Network (ANN) the field of pattern recognition initiated with perceptrons. Previously neural networks have been used externally in pattern recognition, but in recent years this has become the method of choice in pattern recognition applications due to recent progress in learning algorithms and high speed processing hardware. Since most of the problems in pattern recognition are very complex and time consuming when solved through hand crafted algorithms (Yadollahi and Procházka, 2009), the machine learning algorithms have been developed for speedy computation in such applications of pattern recognition. The machine learning automatically synthesizes a classification function from a set of associated class labels.

Object Classification is an image categorization procedure which consists of identification of any object by using a set of suitable features. The precision of object classification system deteriorates when the image is degraded and deformed by different factors such as variation in illumination, intra-class variability, cluttered background, translation, scale invariance, rotations, occlusions etc. These factors influence adversely the object classification. There is lot of intra-class variability while representing the images by low level features as color, histogram etc. Such a representation is not robust enough to discriminate amongst different object categories. Many different approaches and feature extraction models related to object classification have been proposed and applied during the last decade but most of them discuss the object classification without any degradations or deformations.

Multiclass Object classification in still, gray scale images has been the interest of researchers for the last decade. The problem of the object recognition has been approached using part and shape model that represents the appearance of individual components and spatial relation between them (Agarwal and Roth, 2002). Another attempt has been made to make use of a , sparse, part based representation of learning of objects amidst clutter and mild occlusion (Agarwal et al., 2004). The computation time is a factor which is to be reduced in both the papers. One of the shape feature extraction approach (Dalal et al. 2005) computed good experimental results in detection of MIT

pedestrians with accuracy by introducing Histogram of Oriented Gradient (HOG) descriptors.

Gray-Level Co-occurrence Matrix (GLCM) is used as a statistical texture measure for Synthetic Aperture Radar (SAR) imagery (Zhang et al., 2009). Color histograms are widely used for retrieval of results based on queries. For such queries, color histograms can be employed because they are very efficient in computations and insensitive to small changes regarding camera position (An et al., 2008). But the main problem with color histograms is their coarse characterization of an image. That may itself result in same histograms for images with different appearances. Color histograms are employed in systems such as QBIC, Chabot. They all utilize the advantages of color histogram. In this study, they used a modified scheme based on color histogram. A modified method based on histogram refinement is used by Jeyanthi et al. (2010). In this method the pixels within a given bucket are splited into classes based upon some local property and these split histograms are then compared on bucket by bucket basis just like a normal histogram matching but only the pixels within a bucket with same local property are compared. So the results are better than the normal histogram matching. Not only the color features of the image are used but also the spatial information is incorporated to refine the histogram. Prabhu and Kumar (2013) proposed a method for content based image retrieval using color and texture based on wavelet coefficients.

The aforesaid features extracted from the images are used for classification of objects from various object classes. A classifier refers to a computer program in which a specific algorithm is implemented for image classification (Campbell, 2002). The analyst must select a classification method that will best accomplish a specific task. In general, it is not possible to state which classifier is the best for all situations as the characteristic of each image and the circumstances for each study may vary significantly. Therefore, it is essential that each analyst understand the alternative strategies for image classification so that one may be prepared to select the most appropriate classifier for the task in hand. These techniques in ANN are distinguished in two main ways (Jain et al., 2012).

(i) Supervised Classification in which input pattern is identified as a member of predefined class.

(ii) Unsupervised Classification, in which input pattern is assigned to an unknown class.

Chaplot et al. (2006) conducted experiments to detect brain tumor by combining two techniques feed forward neural network and back propagation neural network. The results obtained, shown that these methods can be used to filter out non-suspicious regions that have similar property as the tumor regions. Al-Hadidi et al. (2012) used hybrid ANN and image processing technique to detect breast cancer based on the mammography. Likewise, Sarhan (2005) proposed a system to detect stomach cancer based on artificial neural network (ANN) and discrete cosine transform (DCT).

2. Motivation

Multiclass object classification system is a very necessary component of computer vision system in artificial intelligence using machine learning technique. An application of the multiclass object classification system is content based image retrieval, which requires the image retrieval by the feature descriptors from trained images. Features required for object image retrieval may be degraded during image acquisition, transmission or by other means. In this situation the features to be selected must be robust enough to reduce the impact of these degradations or deformations. Here degradation of an image means that it is corrupted by noise or blur. Deformation refers to the transformation of object geometrically such as rotation, shearing, scaling etc or presence of partial occlusion. In this thesis, the various feature extraction methods and classification model of ANN have been presented to handle following degradation and deformation issues

(i) Noise
(ii) Blur
(iii) Affine Transform
(iv) Cluttered Background
(v) Partial Occlusion

3. Objectives

This research investigates the efficacy of the various feature extraction algorithms used in multiclass object classification system and proposes a Neural Network based classifier to improve the classification accuracy. The proposed classification model is

tested using standard database such COIL-100, Caltech etc. The work is classified into the following objectives:

(i) Propose a Multiclass object Classification system of noisy images.

(ii) Propose a classification system to classify the object images affected with blur.

(iii)Construct a classification system to classify the affine transformed images.

(iv)Framing of a classification system invariant to object having complex background.

(v) Designing of a classification system to classify object images having partial occlusion.

4. Description of the Research Work

The solution for the problem of object classification is based on key feature extraction of object. This thesis states the multiclass object classification that is based on various feature extraction methods under different constraints such as presence of noise, blur, partial occlusion, clutter background and affine transform. The performance of the classification model is tested with the image databases COIL-100, Caltech and UIUC as discussed in subsequent section. An algorithm Morphological Operation Based Object Mapping (MOBOM) has been proposed for mapping of an object of interest under cluttered background. A schematic structure of the classification model is presented in the Fig 1.

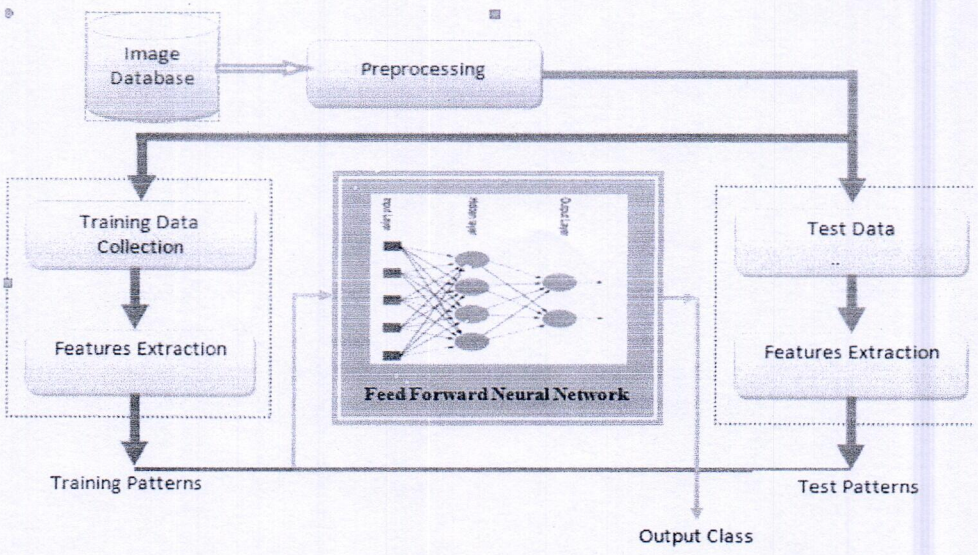

Fig 1: Image Classification Approach

In view of the objectives of the thesis mentioned in section 3, the classification of multiclass degraded and deformed object images, mainly two categories of databases has been considered as the model data set to evaluate the classification accuracy of classification system, one with no cluttered background and other with partially cluttered background. For this purpose Columbia Object Image Library (COIL-100) (Nayar, S. K. et al. 1996) without cluttered background and those of Caltech Categories of Computational Vision standard database, University of Illinois at Urbana-Champaign (UIUC) database (Agarwal et al. 2004) and California Institute of Technology Caltech Database (Fei-Fei et al. 2004) respectively with cluttered background have been used.

To validate the performance of the model noisy image database is developed by imposing some intensity of noise in the original images. The sample test images with noise are show in the Fig 2(a). The noisy image database is prepared with Gaussian noise of zero mean and variance between 0.01 to 0.10. A database is developed to test the performance of blurry object classification model. Sample images affected with Gaussian blur are shown in the Fig 2(b).

(a) Sample Test object images fabricated with Gaussian Noise

(b) Sample images from the blur image database

Fig 2: Sample Degraded object images

To evaluate the performance of the proposed method on the images distorted by affine transform, a synthetic database is developed from original images as shown in Fig 3(a). Sample object images having partial cluttered background are shown in the Fig 3(b).

(a) Sample images from Affine transform image database

(b) Three object class Sample images with complex background

Fig 3 : Sample Deformed and Cluttered background images

COIL-100 data set images are deformed through occlusion created by various shapes present in paint brush (windows application) to test the performance of the multiclass object classification under partial occlusion. Sample Images are shown in Fig 4.

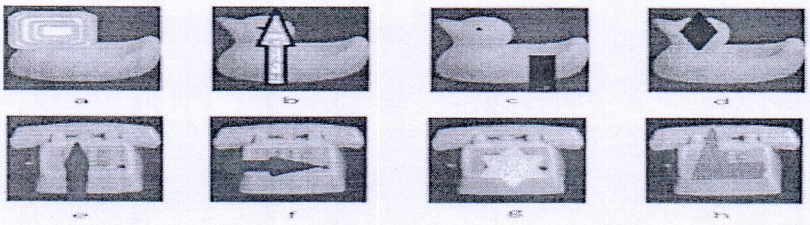

Fig 4: Sample object images with partial occlusion

4.1 Multiclass Object Classification of Noisy Images

As the noise affects the performance of the classification accuracy object classification in presence of anonymous noise is carried out as first objective of the thesis. This superfluous information e.g. additive noise may occurs in images due to image sensors that is of the constant noise level in dark areas of the image; or salt & pepper noise may be caused by analog to digital conversion and bit error transmission etc. So, it becomes very necessary to remove anonymous noise before applying feature extraction algorithm. This work presents two methods of noisy object image classification. In the first method, an approach for noise type detection is proposed, which is followed by statistical moment based feature extraction and object classification. Wavelet based feature extraction of images is introduced for noisy object image classification in the second method. Images are degraded through Gaussian noise for performance evaluation of the neural classifier. Classification accuracy of multiclass images is examined and the results are obtained under various constraints such as with noise, without noise and filtered images. The results are compared and important inferences are drawn. Wavelet feature based classification approach produced higher classification accuracy of 96.5% as compared to statistical moment based approach which gives 95.4%t. Similarly in presence of noise also wavelet based method shown robustness over first approach giving the accuracy 95.4%.

4.2 Multiclass Object Classification of Affined Transformed & Blurry Images

Images deformed due to geometrical transform, blur contamination or the combination of both have been considered and two approaches have been applied for multiclass

object classification of images. Wavelet features have been utilized for classification in first approach. The second approach utilized Blur and Affined Invariant moment descriptors in spatial domain, which are invariant to centrally symmetric blurs. The performance of the system is demonstrated through various experiments. Three experiments are conducted to evaluate the potential of the feature extraction methods. The first experiment deals with the object classification in the images deformed through geometrically transformed i.e. affine transform. In the second experiment, the effect of blur is evaluated in terms of classification accuracy. Lastly in the third experiment the performance of the system is examined on the images having combination of both degradation through blur introduction as well as shape deformation through affine transform. The graph shown in the Fig 5 shows the performance of one of the experimental results in terms of classification accuracy. This compares the performance of two methods: wavelet based feature extraction and another as Combined Affined Blur Invariant Moment features.

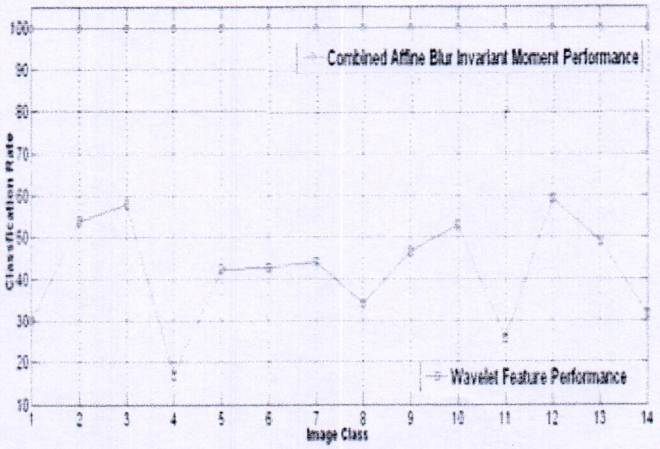

Fig 5: Performance comparison of two methods on affine transformed and blurry images

4.3 Multiclass Object Classification having Partial Cluttered Background Images

The next objective of that is building of multiclass object classification system under complex background includes four steps: preprocessing, object mapping, feature extraction and classification. The preprocessing includes converting images from colored to gray scale and resizing of image. While object mapping process removes

background scene through MOBOM. This isolates the object from extra information like complex background. A blocking model with varying size of blocks is presented for feature extraction of the image after pre processing of the image. The Curvelet features are extracted from each of the block of the image to build a feature vector of the image. A neural network based classifier is developed with appropriate number of input layer, hidden layer and output layer for training. The comparisons of the performance with other methods are demonstrated through graph in Fig 6. The robustness of the proposed model has been analyzed by the accuracy of the results of various experiments displayed in the Fig 6.

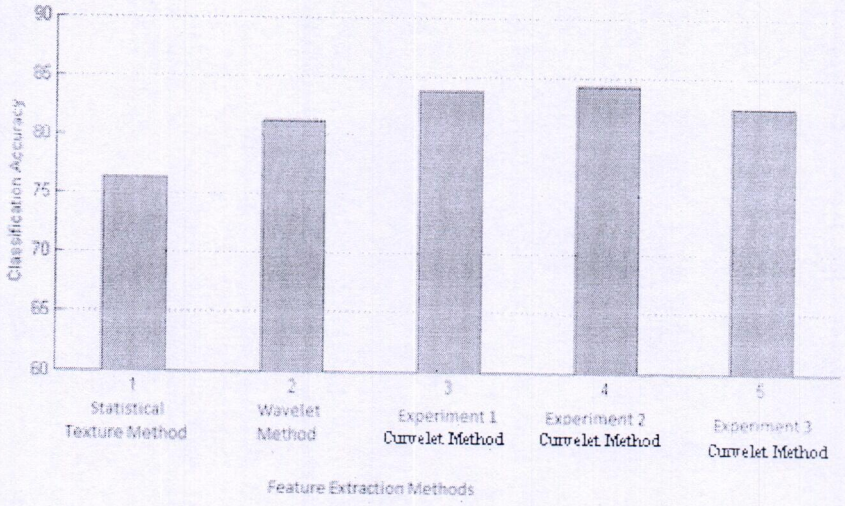

Fig 6: Classification accuracy in different feature extraction methods

The experiments 1, 2 and 3 correspond to curvelet based features based methods and show better classification accuracy than those of traditional classification techniques as statistical texture method and wavelet method.

4.4 Multiclass Object Classification under Partial Occlusion

In order to accomplish the fifth objective Wavelet based Histogram of Oriented Gradients (WHOG) feature descriptors are proposed to represent shape information by storing local gradients in image. This results in enhanced representation of shape information. The performance of the feature descriptors are tested on multiclass image data set having partial occlusion, different scales and rotated object images. The

performance of WHOG feature based object classification is compared with HOG feature based classification (Dalal and Triggs, 2005). The matching of test image with its learned class is performed by using Back Propagation Neural Network (BPNN) algorithm. Proposed features based method not only performed superior to HOG but also beats wavelet, moment invariant and curvelet based techniques. WHOG feature based method performs better than HOG features based as shown the performance of the methods in the Fig 7. In the first method, multiclass object classification under no partial occlusion produces 96.7% accuracy and 82.1% classification accuracy for occluded image database. The second method i.e. WHOG based features extractor gives 94.18% of classification accuracy for unoccluded image database and 89.21% for occluded image database. This shows the robustness of WHOG feature based method over that HOG feature based method for classification under partial occlusion.

5. Conclusion

Multiclass object classification system has been effectively implemented to classify objects from deformed and degraded images. Multiclass object classification of images has been carried out under different constraints such as in presence of noise, cluttered background, partial occlusion, blur and geometrical transformation. The implemented classification models utilize feed forward neural network with Back Propagation Algorithm and applies various feature extraction schemes. The performance of the proposed classification models are tested on different standard object image datasets and compared with existing methods of feature extraction and classification. The proposed models exhibit the superior classification accuracy over other approaches.

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object classification. This chapter provides a solution as combined moment invariant to blur and affine transformed based feature extraction technique to overcome the problem occurred in classification of geometrically distorted objects such as rotation, translation, shearing separately or in combination. Various experiments are conducted in this chapter to show the robustness of the proposed method over the other existing methods.

Chapter 6*: *Object Classification of Images having Partial Cluttered Background

The objective of this chapter is to construct a classification system for identification of multiclass object images surrounded by complex back ground. Here an object localization method to extract the boundaries of the object of interest is proposed followed by curvelet based feature extraction for image classification.

Chapter 7*: *Object Classification under partial occlusion

In this chapter classification of the object images is performed, which are partially occluded by some other objects or hidden. In this chapter a wavelet based histogram of oriented gradients HOG feature descriptors are proposed to represent shape information by storing local gradients in image. This results in enhanced representation of shape information. The performance of the feature descriptors are tested on multiclass image data set having partial occlusion, different scales and rotated object images also.

Chapter 8*: *Conclusions and Future Work

Finally, this chapter summarizes the contents of the present PhD thesis and discusses its contribution. It also identifies areas for future work and makes suggestions on how to take this work forward.